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ABSTRACT

The effectiveness of a Keller and Bloom mastery learning program for high school science students was examined by comparing remediation strategies of both programs and that of a traditional strategy. The data gathered in the experiment in chemistry were from a pre- and post-achievement test. Cognitive achievement was statistically different ($p < .025$). Additional analysis revealed the greatest difference was between a Bloom and a traditional strategy. Gain score analyses failed to produce any significant differences. A Chi-square analysis of the number of objectives achieved produced significant values of .004 and .034, respectively, for the Keller and Bloom groups over the traditional group. (Author/RH)

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A Comparison of Mastery Learning Feedback Systems Affecting Achievement in Chemistry

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Abstract

The purpose of this investigation was to determine the influence of different remediation strategies on student retention of cognitive achievement. Fifty-three students enrolled in a high school regents chemistry course were randomly assigned to three treatment groups (Keller group, Bloom group, and traditional group).

The procedure consisted of a sixteen week orientation phase which preceded the experimental phase of the investigation. Mastery techniques and procedures were introduced to students during the orientation period to enable them to operate with confidence and facility involving different remediation strategies before the experimental phase commenced. The beginning of the two and one half week experimental phase coincided with the administration of the chemistry achievement test over the unit on kinetics and equilibrium. Content for this test and for the subsequent remediation strategies were structured by the New York State Regents Syllabus.

Cognitive achievement measured by student performance on the Chemistry Achievement Test administered at the conclusion of the experimental phase was significantly different ($p < .025$) for the three treatment groups. Additional analyses revealed that although substantial improvement had occurred in all treatment groups, the most pronounced difference occurred between the group following the Bloom remediation strategy which outperformed the traditional remediation group.

Achievement determined by gain-scores obtained from administration of the Chemistry Achievement Test at the beginning and conclusion of the experimental phase failed to produce a statistically significant difference between the three groups.

A third measure of student achievement based on the number of objectives achieved by group members of the three treatment groups produced significant chi-square values between the three groups with the Bloom and Keller groups outperforming the traditional group with .004 and .034 levels of significance respectively.

Block (1971) proposes that there is considerable research suggesting that it is unwise to allow students to continue a frustrating experience of unsuccessful and unrewarding school learning. Years of repetitive negative experiences only serve to destroy the student's chances for success and survival in his or her field of endeavor.

At present, two mastery schools, developed separately but simultaneously, are attempting to compensate for some of the shortcomings of our educational system. Learning for Mastery or LFM proposed by Benjamin Bloom (1968) offers an alternative approach to the aforementioned problem. This approach can provide the success and positive reinforcement necessary for survival in our society by describing procedures which offer all students the opportunity to achieve at the same high level as the top 25 percent of students in traditional classrooms.

Personalized System of Instruction or PSI, as an alternate form of mastery learning, proposed by Fred Keller (1968) also prescribes procedures and methods to attain the same high achievement level and to develop an increased positive attitude toward instruction and learning in schools.

Theories of mastery learning proposed by Brunner (1966), Carroll (1963), Goodlad and Anderson (1959) have been interpreted by Bloom (1968) and incorporated into his cooperative approach to Mastery Learning. Keller, probably inspired by B.F. Skinner's paper, "The Science of Learning and the Art of Teaching" (1954), and joined by one of his former graduate students, J. Gilmore Sherman, first tested PSI in Brazil. Keller and Sherman, along with two Brazilian colleagues Rodolfo Azzi and C. M. Bori, planned and instituted the first PSI Course in an elementary psychology course at the University of Brazilia (Ruskin, 1974). Upon his return to the United States, Keller (1968) wrote his well-known article "Good-bye Teacher" and educators began to take notice of his ideas. Ideas stressing communication by the printed word, perfection, self-pacing, use of proctors; along with motivating rather than informative lectures, were the basis of a highly individualized and personalized mastery learning program. It is a primary objective of this study to compare and contrast the two popular approaches to mastery learning: Keller's PSI and Bloom's LFM.

Subjects

The subjects for this comparison were 53 high school students enrolled in regents chemistry in Victor, New York during 1974-75 academic year.

The instructor was the investigator. The students, having completed a course in elementary algebra, were in their junior or senior year. Most students had finished a year of geometry and had either taken or were concurrently enrolled in a course of intermediate algebra and trigonometry. In addition, students had passed two full years of science including courses in physical science and biology. The students differed mainly in their past achievement and interests and were enrolled in two classes that met four class periods and two laboratory periods per week. A random number generator was selected to create three groups of students and to assign the treatments.

Procedure

The investigation was preceded by a sixteen-week orientation phase. During this period, students experienced a mastery learning strategy in order to become familiar with behavioral objectives, various feedback techniques and remediation procedures, group and individualized tutorial sessions, and the use of compulsory review classes. The orientation period was used to reduce the possibility of a Hawthorne effect and to make a smooth transition into the experimental phase.

During the instructional phase, both group and individualized procedures were used. The instruction took place over a period of thirteen days while the remediation period took five days. The posttest which followed the instructional period was administered as the test of retention eighteen days following the initial evaluation.

Students were assigned five behavioral objectives to master in a chemical equilibrium and kinetics unit. The objectives were submitted at the onset of the instruction period. Instruction was accomplished in eleven class periods of forty-five minutes each and two laboratory sessions of ninety minutes each. During the two laboratory sessions, two separate experiments related to the objectives, i.e., Reaction Rates, a Study of Chemical Equilibrium, were conducted by the students.

Two Laboratory reports based on the above experiments and one problem assignment were submitted during the instructional period. Student papers were corrected and returned to provide additional feedback. Two formative evaluation instruments were administered during instruction and also provided feedback to each individual prior to the posttest concluding the instructional phase.

Treatment

The three groups which received identical instruction and materials through the first summative evaluation differed only in remediation strategy used as described here as treatments one, two, and three.

Treatment No. 1: The non-mastery group did not receive further instruction based on the objectives but were offered a traditional option. To improve grades and understanding, a library assignment was recommended consisting of a voluntary, extra-credit research assignment describing commercial reactions involving the concepts represented in the behavioral objectives. The assignment was performed during the class time of the remediation period.

Treatment No. 2: The second remediation was modeled to emanate a Bloom remediation strategy. Students who did not reach mastery on the summative evaluation were given class time to work in small groups using the knowledge of the objectives achieved, cooperative peer tutoring with successful students as group leaders, self study, alternative learning materials, and teacher aided instruction aimed at the unattained objectives to make it possible for all members to reach an eighty percent mastery level on a second summative evaluation. Participating students selected an examination time when they were confident. All examinations were keyed to the five objectives. Students not succeeding on this attempt were required to attend a special review session with the instructor, scheduled outside of class time. This review activity was followed by a third summative evaluation when the student felt prepared. The third evaluation was the final opportunity used to determine whether mastery had been attained.

Treatment No. 3: The Keller Plan for remediation and third treatment group also received two additional opportunities to achieve mastery. Each evaluation was again keyed to the objectives; students who did not reach mastery on the initial summative examination were given the same instructional materials and instructed to individually repeat the assignments, study the problem assignments and laboratory reports, and review the teacher aided instructional notes. Whenever the students felt confident, they requested subsequent evaluations with the third evaluation being the final evaluation for mastery.

Mastery Tests

The data gathering instruments used were constructed by the investigator and consisted of pretested questions from prior New York State regents examinations. A pool of questions consisting of sixteen questions for each of the five objectives was selected from the previous seven years of regents examinations in chemistry. The items, therefore, had been piloted on students who had completed an equivalent course in chemistry. All questions were reviewed by three other chemistry instructors from other schools and verified to be representative of the objectives.

From this pool of eighty items, parallel examinations were constructed by randomly selecting twenty-five questions for each of two evaluation instruments. One examination was used as the posttest and the retention test. The second examination was used to determine mastery following remediation. The internal consistency estimation of reliability based on the retention test data revealed a reliability coefficient of .791 using the Kuder-Richardson formula-20 (Guilford, 1965).

Measures of Achievement

The performance measures used for evaluation of hypotheses one and two were the posttest and retention test in a three group design. A one-way analysis of variance and F-test of significance was used for hypothesis one and two at the .05 level of significance, and t-tests were conducted to determine the specific treatments responsible for any differences (VanDalen, 1966). The third hypothesis was tested by a contingency table and chi-square statistic at the .05 level of significance (VanDalen, 1966).

In order to establish a contingency table, it was necessary to determine a specific number of questions to be used to determine mastery. Because questions were randomly selected for the criterion measures, it was necessary to select a specific number of correct responses to be used to determine mastery of each objective. The number of correct responses per objective was selected to be close to the mastery level with an overall average resulting in eighty-four percent.

Statistical Hypotheses

The statistical hypotheses developed for analysis are presented as follows:

1. HO: There will be no significant difference in retention scores in regents chemistry among treatment groups exposed to different remediation strategies measured by a retention test.
   H1: Students in regents chemistry will achieve greater retention scores in groups utilizing mastery instructional strategies than students following a traditional instructional strategy.
2. HO: There will be no significant difference in the change in achievement scores between treatment groups as measured by a posttest and a retention test.
   H1: Students participating in one of the mastery strategies will demonstrate a greater increase in achievement scores between the posttest and the retention test than students utilizing a traditional strategy.
3. HO: There will be no significant difference in the total number of objectives mastered by the treatment groups taught by different instructional strategies.
   H1: Students participating in one of the mastery strategies will achieve a greater number of objectives than students following a traditional instructional strategy.

Analysis

The analysis of the first statistical hypothesis was performed using a one-way analysis of variance and a multiple comparison test of pooled variance. Table 1 lists the means, standard deviations and

sample size of the total group and each treatment group on the posttest and retention test.

Table 1

Means, Standard Deviations and Sample Size of Group Scores on the Chemistry Achievement Instrument

	Keller	Control	Bloom
N =	18	18	17
Posttest:			
X =	14.056	13.889	15.588
SD =	3.621	3.787	3.222
Retention test			
X =	19.389	17.444	21.059
SD =	3.883	4.668	2.487

The analysis of variance yielded an F ratio of 3.949. This resulted in a significant probability of .025. The null hypothesis was therefore rejected at the .05 level of significance. The data for this analysis is provided in Table 2.

Table 2

Analysis of Variance of Student Achievement Determined from Retention Test Scores

Source	df	SS	MS	F	P
Between groups	2	114.637	57.318	3.949	.025
Within groups	50	725.672	14.513		
Total	52	840.309			

In order to determine which treatment was responsible for the significant difference reported for Hypothesis 1, separate comparisons of means and t-tests for the three interactions were performed and are reported in Table 3. The traditional treatment was considered the control group for this analysis.

Table 3

Multiple Comparison t Values for Retention Test Results Related to Hypothesis 1

Variable	t value	df	p
Keller-Control	1.36	34	.183
Keller-Bloom	1.50	33	.142
Bloom-Control	2.83	33	.008

Both the Keller-Control and Keller-Bloom comparisons were found not to be the cause of the significant F ratios. However, a significant t value of 2.83 and a probability of .008 is reported for the Bloom-Control comparison and was credited as the cause of the significant F value.

The change in achievement scores between the posttest and the retention test was investigated in the second hypothesis. Table 4 contains a summary of the descriptive data for achievement gains.

Table 4

Difference Means and Standard Deviations of Group Scores on the Chemistry Achievement Instrument, Posttest and Retention Test Administration

	Total	Keller	Control	Bloom
N	53	18	18	17
X	4.774	5.333	3.556	5.471
SD	3.771	3.498	3.989	3.710

A one-way analysis of variance was performed to test the difference between means of the three treatment groups and revealed an F ratio of 1.453 and a probability of .242. Consequently, the null hypothesis was accepted for hypothesis 2.

Table 5

Analysis of Variance of Student Gain in Achievement from Posttest to Retention Test for Hypothesis 2

Source	df	SS	MS	F	P
Between groups	2	40.603	20.302	1.453	.242
Within groups	50	698.680	13.974		
Total	52	739.283			

The third hypothesis evaluated the number of objectives achieved. The number of questions answered correctly to determine mastery is reported in Table 6.

Table 6

Objectives and Number of Questions Required for Mastery

Objective	Questions required for Mastery	Percent Mastery	Total Average Percent
1	3 of 4	75.0	
2	5 of 6	83.3	
3	3 of 3	100.0	84.4
4	6 of 7	85.7	
5	4 of 5	80.0	

A 2 x 3 contingency table and chi-square statistic with two degrees of freedom was used to test the significance of the number of objectives achieved by students in the three treatment groups. The chi-square statistic for hypothesis 3 was 14.555 (p .001). The third hypothesis

was rejected at the .05 level of significance. The contingency table and chi-square value for hypothesis three is stated in Table 7.

Table 7

Chi-Square Value and Frequency of Objectives Mastered from the Retention Test Results by Treatment Groups

Group	Mastered	Not Mastered	Total Assigned
Keller	53	37	90
Control	39	51	90
Bloom	61	24	85
Total	153	112	265

Chi-square value = 14.555
Probability = .001

In order to determine the cause of the significant chi-square statistic, three additional 2 x 2 chi-square values with one degree of freedom were calculated between the three groups. The Keller-Control chi-square value was 4.358 with a probability of .034; the Bloom-Control chi-square value was 14.429 with a probability of .0004; and the Keller-Bloom chi-square value was 3.192 with a probability of .070. The post-hoc analysis revealed that both the Keller and Bloom mastery treatments resulted in significant objective mastery when compared to the objectives mastered by the traditional group. It is also noted that the Keller-Bloom comparison did not yield a significant chi-square value. The summary of the three contingency Tables are presented in Table 8.

Table 8

Chi-Square and Frequency of Objectives Mastered
by Pairs of Treatment Groups from the Retention Test Results

Group	Mastered	Not Mastered	Total Assigned
Keller	53	37	90
Control	39	51	90
Total	92	88	180
Chi-square value = 4.358 Probability = .034			
Bloom	61	24	85
Control	39	51	90
Total	100	75	175
Chi-square value = 14.429 Probability = .0004			
Keller	53	37	90
Bloom	61	24	85
Total	114	61	175
Chi-square value = 3.192 Probability = .070			

Discussion

This study was conducted to determine whether students exposed to different learning strategies in a secondary school chemistry course would demonstrate different levels of retention of the subject and would achieve different numbers of objectives. The strategies consisted of a Keller feedback and remediation strategy, a Bloom feedback and remediation strategy and a traditional feedback and extra-credit research strategy. The results indicated that all three groups made substantial performance gains. These results would suggest that feedback and remediation in a mastery strategy or traditional strategy as used in this study can have a positive effect on student achievement and retention.

As a result of the analysis for the first hypothesis, it was discovered that a Bloom strategy can improve achievement of students when compared with a traditional strategy. The results of the Bloom-Control comparison are consistent with the research findings on retention of Block (1972), Kersh (1971), Romberg, Shepler and King (1970), Romberg and Shepler (1973), Wentling (1973) and Janczarek (1973). The results of the Keller-Control statistical evaluation are not in agreement with the experimental results reported by Corey and McMichael (1974). Austin and Gilberg (1973) and Leo (1973) also report superior results in a Keller study on retention examinations but did not present statistical data to support their findings.

Efforts to discover any experimental results comparing Bloom and Keller strategies have been unsuccessful with one exception. This exception was reported by Block (1974) of a study by Tierney and stated that no significant differences exist in student ability to recall course material between a Bloom and Keller mastery strategy. The results of the current study would also support this data.

In investigating the second hypothesis, only a study by Beul (1974) was uncovered that utilized a gain score approach in the evaluation of a mastery strategy. Buel reported superior results by a Bloom strategy when compared to a traditional control group. The direction of improvement in this study agrees with the Beul study, but the F ratio indicates that the latest investigation is not consistent with the significant finding reported by Beul.

Analysis also indicates that a Keller and a Bloom strategy can increase the total number of objectives achieved by students when compared to a traditional strategy. A review of the research on mastery learning failed to reveal any similar findings involving objectives mastered related to the mastery strategy utilized. Only the study by Denton and Gies (1975), was found in the literature which considered the measurement of objectives achieved as a variable for statistical analysis.

All three treatments in this study demonstrated large increases in achievement as a result of the use of remediation strategies. A review

of the literature indicates that a great deal of the research on mastery strategies ignores the use of any directed remediation strategy in traditional classrooms. This researcher feels that a large quantity of the current mastery research is vague in the definition of a "traditional" treatment. This shortcoming creates an unfair comparison in favor of mastery strategies based on the concept that drill and practice exercises will increase student achievement in a given subject. Researchers should expect greater gains by mastery learning treatments when compared to a treatment with no remediation exercises.

It is a distinct possibility that the increased achievement which is demonstrated by mastery strategies is greater than that of the traditional strategy in this study due to motivational influence. The knowledge that students can improve their grade by remediation and retesting without being penalized by an initial low grade may increase student effort and time spent in preparation for recycle examinations.

In summary, present results suggest that student achievement is influenced by the opportunity to remediate upon receiving feedback from initial summative evaluation. Strategies used in mastery learning are especially effective in improving student achievement by increasing student time spent in this remediation. Of the two mastery strategies, the LFM model of remediation is significantly better than the traditional strategy used in this study. This improvement is demonstrated in greater achievement scores on a retention test and by greater achievement in the number of objectives mastered. The PSI model of remediation is significantly better than the traditional strategy as demonstrated by greater achievement in the number of objectives mastered. Neither a Bloom nor a Keller remediation strategy will result in significantly greater achievement when compared to each other.

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